Contribution to the Cytotaxonomical Knowledge of the Genus *Pinguicula* L. (Lentibulariaceae): a Synthesis of Karyological Data

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This paper aims to summarize and briefly analyse the actual karyological knowledge of the genus *Pinguicula* L.

The checklist presented (Table 1) shows all the species of this genus, which have been karyologically studied, in alphabetical order. There are 129 records referring to 35 taxa (30 species and 5 infraspecific taxa). The total of different chromosome counts (considering two or more cytotypes for some units) is 47. The basic numbers are $\times = 6, 8, 9, 11$ (Table 2).

Examining the data in Figure 1 indicates that 14 taxa (31.8%) show 2× complement of which 12 are exclusively diploid ($2n = 12, 16, 18, 22$); 3 taxa (4.6%) show 3× complement of which none is exclusively triploid ($2n = 24$); 20 taxa (45.4%) show 4 × complement of which 14 are exclusively tetraploid ($2n = 32, 44$); 3 taxa (6.8%) show 6× complement of which 2 are exclusively hexaploid ($2n = 48$); 3 taxa (6.8%) show 8× octoploid complement of which 1 is exclusively octoploid ($2n = 64$), 3 taxa (4.6%) show aneuploidy of which none is exclusively aneuploid ($2n = 27, 28, 50$). Furthermore, 34.3% of the considered taxa are diploid, 42.8% tetraploid, 5.7% hexaploid, 2.9% octoploid, 14.3% show two or more cytotypes (representing more or less completely euploid series) or possibility of aneuploidy phenomena.

By comparing the karyological data with the systematic ones synthesized in a recent survey of the genus made by Legendre (2000), we can observe that all the representatives at the base of the tree of the karyological relationships (Figure 2) are characterized by homophylly. The subgenus *Isoloba* is here regarded as probably the most primitive and homogeneous, and is composed of homophyllous species showing tropical growth-type. All the representatives of the subgenus *Temnoceras* show homophylly and the tendency to develop a temperate growth-type together with the polyploidy. The representatives of the subgenus *Pinguicula* show both homophylly and heterophylly and, in the large majority, a temperate growth-type.

A group of species with a neo-basic number $\times = 11$, probably derived from triploid ancestors (cfr. Figure 2), deserves particular attention. Flowing together in this group are two homophyllous representatives with tropical growth-type from the subgenus *Isoloba*, and the four heterophyllous representatives with tropical growth-type from subgenus *Pinguicula* section *Orcheosanthus* (Legendre, 2000).

Unfortunately the karyological knowledge of the genus *Pinguicula* is still partial (only 41.2% of the accepted spontaneous taxa have been studied) and this does not allow us to draw definitive conclusions. As such, to increase the depth of understanding of the cytological knowledge of the genus, it would be very interesting to verify if the peculiar group with $\times = 11$ continues to maintain the characteristics of isolation from other groups. In this case probably this complex would deserve to be separated in some way from others.

The species with lower chromosome number, and probably the most primitive, is *P. lusitanica*, $2n = 12$.

The polyploidy is a phenomenon independently evolved in the three subgenera. The aneuploidy is generally ascendant, and it involves two or three couples of chromosomes.

Pinguicula crystallina is confirmed to be the species in absolute more variable from a cytological point of view, and moreover most of the variability is represented in *Pinguicula crystallina* subsp. *hirtiflora*.

Pinguicula balcanica seems to have two basic numbers (Table 1): this suggests an accurate systematic review of this species, aimed to clarify if this karyological variability is linked to some misidentification or to the union of more taxa under this species.

Table 1: Updated synthesis of karyological data for the genus *Pinguicula* L. (Lentibulariaceae). Nomenclature is according to Schlauer (2002); names originally used by the authors are kept in square parenthesis.

species	infraspecific taxa	chromosome number	source of material	Authors
1 *P. alpina* L.		2n = 32	Scandinavia	Löve & Löve, 1944
			France	Doulat, 1947
				Zurzycki, 1953
			Iceland	Löve & Löve, 1956
			USA	Wood & Godfrey, 1957
			Poland	Skalinska et al.,1959
			Russia	Sokolovskaja & Strelkova, 1960
			Austria	Casper, 1962
				Casper, 1963a
			Finland	Sorsa, 1963
			Norway	Laane, 1965
				Casper, 1966
			East Sayan	Krogulevich, 1976
			Slovakia	Murin, 1976
				Krogulevich, 1978
			Mongolia	Murin et al., 1980
			Austria	Dobes et al., 1997
2 *P. balcanica* Casper		2n = 24	Greece	Contandriopoulos & Quezel, 1974
		2n = 32	Bulgaria	Casper, 1966
		2n = 44		Heitz, 1926
			USA	Wood & Godfrey, 1957
				Kondo, 1969
3 *P. caerulea* Walt.		2n = 32	USA	Godfrey & Stripling, 1961
				Casper, 1963a
				Kondo, 1969
4 *P. colimensis* McVaugh & Mickel		2n = 22		Kondo, 1969
5 *P. corsica* Bernard et Gren ex Gren et Godr.		2n = 16	Corse	Contandriopoulos, 1957
			Corse	Favarger & Contandriopoulos,
			Corse	Contandriopoulos, 1962
			Corse	Casper, 1963a
6 *P. crenatiloba* A. DC.		2n = 16		Casper, 1963a
7 *P. crystallina* Sibth. et Smith	subsp. *crystallina*	2n = 24	Turkey	Contandriopoulos & Quezel, 1974
		2n = 28	Cyprus	Mikeladze & Casper, 1997
	subsp. *hirtiflora* (Ten.) A. Strid	2*n* = 16	Italy	Honsell, 1959
				Casper, 1962
				Casper, 1963a
			Greece	Contandriopoulos & Quezel, 1974
	[var. *louisii* (Markgraf) Ernst]	2*n* = 24	Greece	Contandriopoulos & Quezel, 1974

Table 1 (continued)

			2*n* = 27	Greece	Strid & Franzen, 1981
				Italy	Peruzzi *et al.*, 2003
			2*n* = 28	Italy	Mikeladze & Casper, 1997
		[var. *gionae* Contandriopoulos et Quezel]	2*n* = 32	Greece	Contandriopoulos & Quezel, 1974
		[var. *megaspilaea* (Boiss. et Heldr.) Schindler]	2*n* = 48	Greece	Contandriopoulos & Quezel, 1974
8 *P. ehlersiae* Speta & Fuchs			2*n* = 32	Mexico	Speta & Fuchs, 1982
9 *P. esseriana* B. Kirchner			2*n* = 32	Mexico	Speta & Fuchs, 1982
10 *P. grandiflora* Lam.	subsp. *grandiflora*		2*n* = 32	France	Doulat, 1947
					Contandriopoulos, 1962
					Casper, 1963a
				Spain	Zamora *et al.*, 1996
		[*P. reuteri* Genty]	2*n* = 32		Contandriopoulos, 1962
			2*n* = 64	USA	Wood & Godfrey, 1957
	subsp. *rosea* (Mutel) Casper		2*n* = 32		Contandriopoulos, 1962
11 *P. gypsicola* T. S. Brandegee			2*n* = 22		Casper, 1963a
					Kondo, 1969
12 *P. ionantha* R. K. Godfrey			2*n* = 22	USA	Godfrey & Stripling, 1961
					Casper, 1963a
13 *P. leptoceras* Reichb.			2*n* = 32		Contandriopoulos, 1962
				Austria	Casper, 1962
14 *P. longifolia* Ram. ex DC.	subsp. *longifolia*		2*n* = 32	France	Doulat, 1947
					Casper, 1962
					Casper, 1963a
				Spain	Zamora *et al.*, 1996
	subsp. *dertosensis* (Cañigueral) Schlauer[1]		2*n* = 48	Spain	Zamora *et al.*, 1996
	subsp. *reichenbachiana* (Schindler) Casper		2*n* = 32	France	Casper, 1962
		[*P. fiorii* Tammaro et Pace]		Italy	Tammaro & Pace, 1987
15 *P. lusitanica* L.			2*n* = 12	France	Contandriopoulos, 1962
					Casper, 1963a
					Kondo, 1969
				France	Schotsman, 1970
				British Islands	Hollingsworth *et al.*, 1992
16 *P. lutea* Walt.			2*n* = 32	USA	Godfrey & Stripling, 1961
					Casper, 1963a
					Kondo, 1969
17 *P. macroceras* Link[2]	subsp. *macroceras*		2*n* = 64	Japan	Uchiyama, 1990
18 *P. moranensis* H. B. et K.		[*P. caudata* Schlecht.]	2*n* = 22		Kondo, 1969
			2*n* = 44		Casper, 1963a
19 *P. mundi* G.Blanca, M.Jamilena, M.Ruiz-Rejón & R.Zamora			2*n* = 48	Spain	Zamora *et al.*, 1996
20 *P. nevadensis* (Lindbg.) Casper			2*n* = 16	Spain	Zamora *et al.*, 1996

Table 1 (continued)

21 *P. planifolia* Chapm.		2*n* = 32	USA	Godfrey & Stripling, 1961
				Casper, 1963a
			USA	Kondo, 1973
22 *P. pumuliflora* C. E. Wood et Godfrey		2*n* = 32	USA	Godfrey & Stripling, 1961
				Casper, 1963a
23 *P. pumila* Michx.		2*n* = 22	USA	Godfrey & Stripling, 1961
				Casper, 1963a
24 *P. ramosa* Miyoshi ex Yatabe		2*n* = 18	Japan	Yoshimura, 1973
25 *P. sharpii* Casper et K. Kondo		2*n* = 16	Mexico	Casper & Kondo, 1977
26 *P. vallisneriifolia* Webb[2]		2*n* = 32	Spain	Löve & Kjellqvist, 1974
			Spain	Zamora *et al.*, 1996
27 *P. variegata* Turcz.		2*n* = 64	Russia	Zhukova & Tikhonova, 1971
28 *P. villosa* L.		2*n* = 16	Norway	Knaben, 1950
			USA	Wood & Godfrey, 1957
		2*n* = 16		Casper, 1963a
			Russia	Zhukova, 1967
			Russia	Sokolovskaya, 1968
			Canada	Löve & Löve, 1982
29 *P. vulgaris* L.	[*P. bohemica* Krajina]	2*n*=32	Czech Republic	Studnicka, 1989
	[*P. bohemica* Krajina]		Czech Republic	Studnicka, 1992
		2*n* = 50		Rosenberg, 1909
				Tischler, 1934
		2*n* = 64	Scandinavia	Löve & Löve, 1944
			France	Doulat, 1947
			Iceland	Löve & Löve, 1948
				Zurzycki, 1953
			Iceland	Löve & Löve, 1956
			USA	Wood & Godfrey, 1957
			Greenland	Jörgensen *et al.*, 1958
			Poland	Skalinska *et al.*, 1959
				Sokolovskaja & Strelkova, 1960
				Casper, 1962
			Austria	Casper, 1963a
				Lövkist, 1963
			Denmark	Larsen, 1965
				Casper, 1966
			Finland	Laane, 1967
				Fedorov, 1969
			Norway	Laane, 1969
			Russia	Sokolovskaya, 1972

Table 1 (continued)

			Canada	Löve & Löve, 1982
				Krahulcovà & Jarolimovà, 1991
	[*P. bohemica* Krajina]			Krahulcovà & Jarolimovà, 1991
	[*P.bicolor* (Nordst. ex Fries) Woloszczàk]			Zurzycki, 1953
30 *P. zecheri* Speta & Fuchs		2*n* = 22	Mexico	Speta & Fuchs, 1982

Notes:
[1]Published under the name *Pinguicula submediterranea* G.Blanca, M.Jamilena, M.Ruiz-Rejón & R.Zamora, see Blanca (2001).
[2]Steiger (1974) published 2*n* = 16 for *P. vallisneriifolia* and 2*n* = 32 for *P. macroceras* subsp. *nortensis* J. Steiger ex J. Steiger & H. Rondeau. These chromosome counts proved to be wrong due to misinterpretation of the chromosome shapes. In reality, *P. vallisneriifolia* has 2*n* = 32 and *P. macroceras* subsp. *nortensis* 2*n* = 64 (Steiger J., pers. comm.).

Table 2: Ploidy levels in *Pinguicula* L.

diploids × = 6	diploids × = 8	diploids × = 9	diploids × = 11	uncertain categorization
P. lusitanica	*P. corsica*	*P. ramosa*	*P. colimensis*	*P. balcanica*
	P. crenatiloba		*P. gypsicola*	
	P. nevadensis		*P. ionantha*	
	P. sharpii		*P. pumila*	
	P. villosa		*P. zecheri*	
	tetraploids (4×)		euploid series	
	P. alpina		*P. moranensis*	
	P. caerulea			
	P. ehlersiae			
	P. esseriana			
	P. grandiflora subsp. *rosea*			
	P. leptoceras			
	P. longifolia subsp. *longifolia*			
	P. longifolia subsp. *reichenbachiana*			
	P. lutea			
	P. macroceras subsp. *nortensis*			
	P. macroceras subsp. *macroceras*			
	P. planifolia			
	P. primuliflora			
	P. vallisneriifolia			
	hexaploids (6×)			
	P. longifolia subsp.*dertosensis*			
	P. mundi			
	octoploids (8×)			
	P. variegata			
	euploid series			
	P. crystallina			
	P. grandiflora subsp. *grandiflora*			
	P. vulgaris			

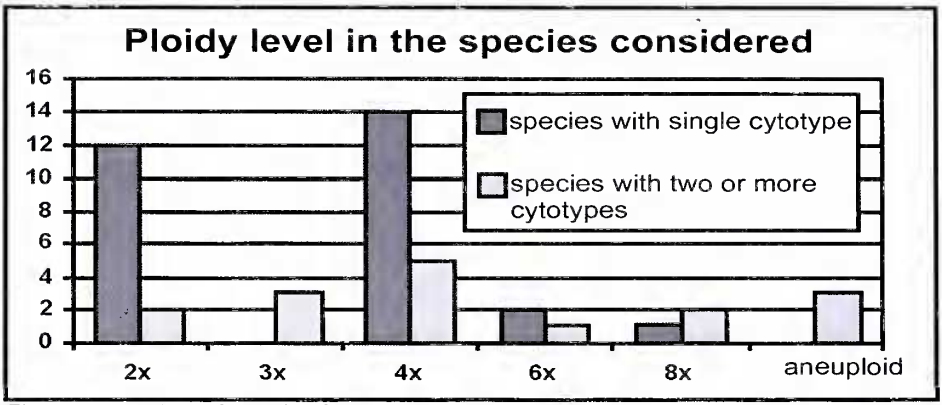

Figure 1: Number of species for every ploidy level, subdivided in species having single cytotypes and species having two or more cytotypes.

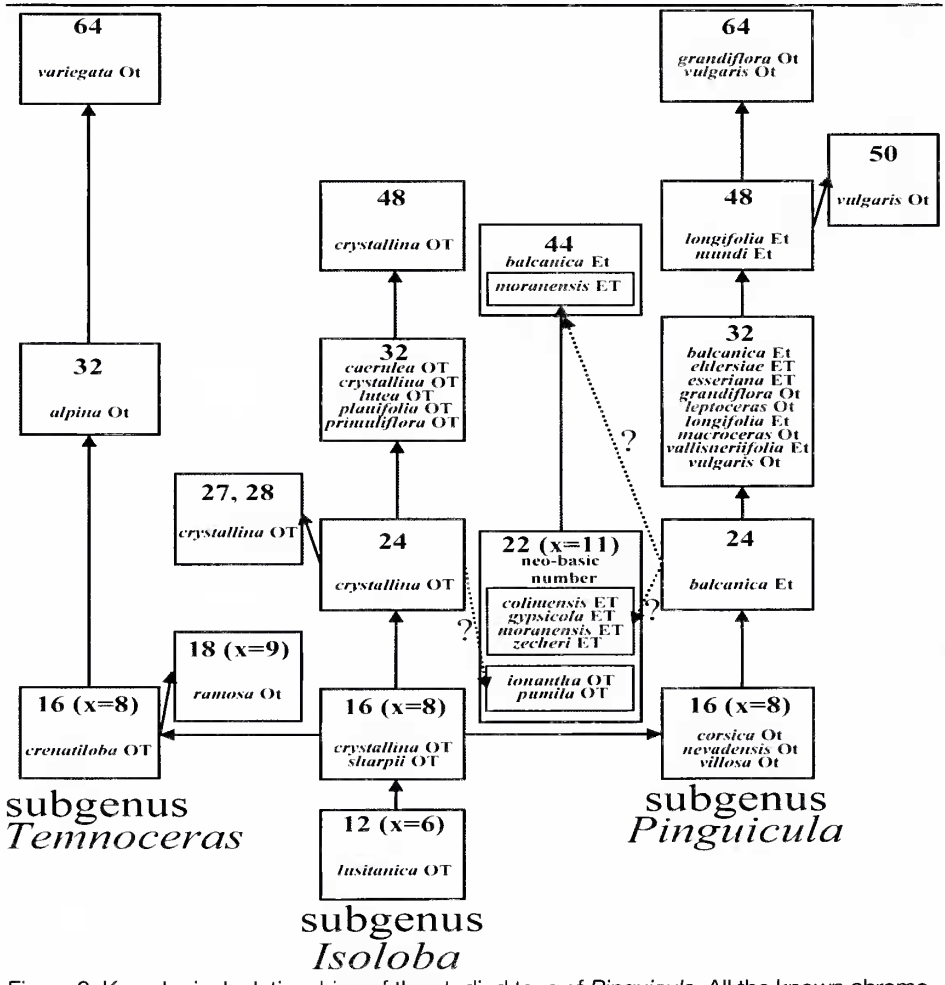

Figure 2: Karyological relationships of the studied taxa of *Pinguicula*. All the known chromosome numbers are organized in a tree subdivided by subgenera. Only specific epithets are cited. OT = homophyllous with tropical growth-type; Ot = homophyllous with temperate growth-type; ET = heterophyllous with tropical growth-type; Et = heterophyllous with temperate growth-type. Extra-karyological information follows Legendre (2000).

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